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ETCHING OF QUARTZ IN THE INTERIOR OF CONGLOMERATES.[1]

General statement.—Those who have studied the Coal-measure and other highly siliceous conglomerates have frequently reported the occurrence of distinct evidences of etching of the quartz pebbles on certain of the exposed surfaces. The portion removed by the etching solutions may amount to as much as nine-tenths of the original pebbles, though one-third to one-half of their mass are more common amounts (Fig. 1). The pebbles affected exhibit strongly pitted and usually very rough surfaces on the exposed parts, while the portions remaining imbedded in the matrix retain unaltered their rounded water-worn characters. The position in which the etched pebbles have been most generally observed is upon the flat upper surfaces of ledges or upon similar surfaces of detached blocks, but instances have been noted, especially in the region about Olean, N. Y., where the etching is also strongly developed on the under sides of overhanging ledges. So far as known the only published discussion of the phenomena is by Dr. C. W. Hayes[2] who regards the etching as a superficial feature due to the action of azo-humic acid under ordinary atmospheric conditions.

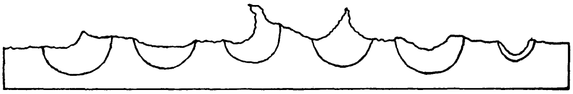

FIG. 1.—Section showing characteristic outlines of etched surfaces. Generalized from surface shown in Fig. 2, *A*.

Character of etching of conglomerate at Blossburg, Pa.—While examining the talus from an outcrop of Pottsville conglomerate at Blossburg, Tioga county, Pa., in 1901, the writer noted certain peculiarities which suggested that the quartz etching might be, in part at least, an internal rather than a superficial feature of the rock. The peculiarities first noted consisted of strongly etched pebbles (Fig. 2, *A*) upon the flat surface of a fragment of conglomerate which, judging from its shape, was a part of a much larger bowlder which had split apart along the etched surface. This seemed to indicate an internal etching along a bedding plane, but could not be regarded as conclusive. Further search, however, brought to light bowlders several feet in diameter in which etched bedding planes could be traced through the mass of the rock. Because of the thickness of the bowlders, specimens of the etched surfaces were difficult to obtain, but the character of the etching in a sandy portion of the rock is shown in the illustrations *B* and *C* of Fig. 2, which are from photographs of specimens taken from opposite sides of an etched plane extending through a bowlder of some size. Not only are the surfaces strongly pitted by the complete removal of a portion of the grains, but under a glass the individual grains, even those of the smallest size, exhibit distinct evidences of etching, either by distinct pittings, or by the general "ground glass appearance" of their surfaces.

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[1] Published by permission of the Director of the U. S. Geological Survey.

[2] "Solution of Silica under Atmospheric Conditions," *Geol. Soc. Am., Bull.,* Vol. VIII, pp. 213–20.

Still further examination brought to light evidences of etching within quarried blocks at distances of five feet or more from the surfaces, but in these cases the etching was confined to the immediate vicinity of plant remains, now carbonized or changed to coal, and, so far as could be detected, was not connected with either etched or unetched bedding or joint planes. The etching, though distinct, was not of the pronounced type characterizing many of the bedding planes (Fig. 2, *A*), but was more of the character shown by the illustrations *B* and *C* of the same plate.[1]

The etching, so far as noted at Blossburg, was confined to the bedding planes or to the vicinity of the vegetable remains in the mass of the rock. The portions of the conglomerate bowlders lying in the humus or exposed to the atmosphere, though sometimes presenting roughened surfaces suggesting etching, proved on examination to be unetched, the roughening being due to the separation of entire grains by the ordinary processes of disintegration. The deep channels and pot-like cavities observed in

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[1] Specimens of quartz pebbles from the Carboniferous conglomerate of Ohio showing strong impressions of plant stems, were exhibited at the Cleveland meeting of the American Association, in 1853, by Professor Jehu Brainerd. These impressions, as urged by Professor J. S. Newberry, were probably due to the action of humic acids evolved during the decay of the vegetable matter, and appear to be of the same nature as the etching about the plant remains in the conglomerate at Blossburg. (See JEHU BRAINERD, *Origin of the Quartz Pebbles of the Sandstone Conglomerate and the Formation of Stratified Sand Rocks*, Cleveland, 1854, p. 16; and J. S. NEWBERRY; *Ohio Geol. Surv.*, Vol. II, Pt. I, 1874, p. 111.

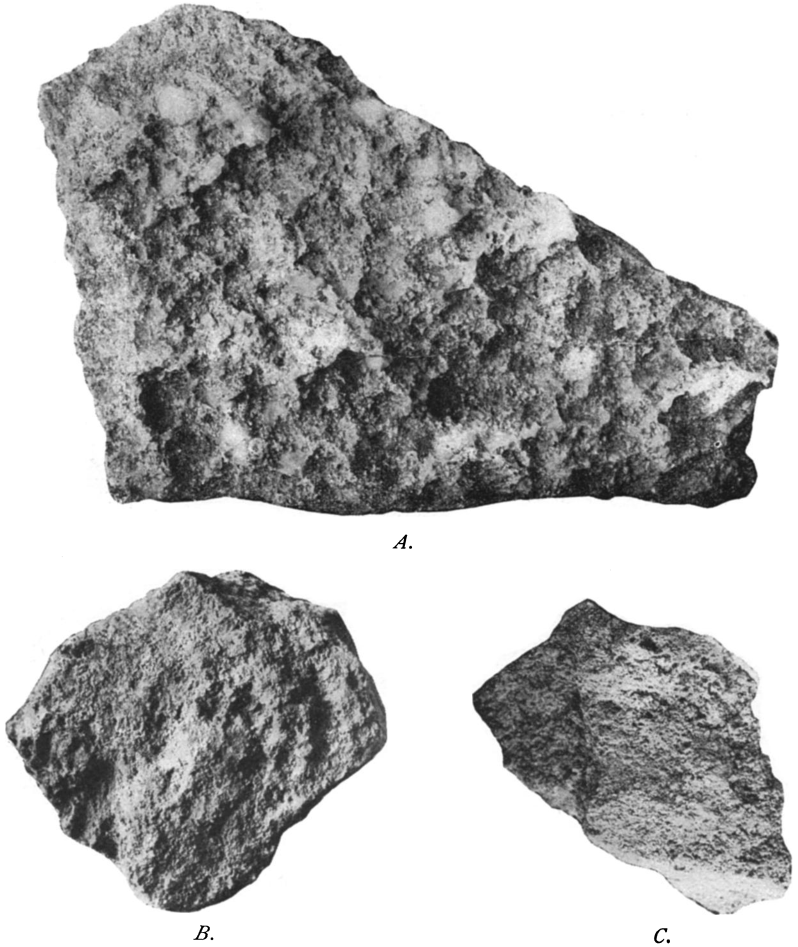

FIG. 2.

A. Etched surface of a bedding plane in Pottsville conglomerate from Blossburg, Tioga county, Pa.

B and *C.* Etched surfaces from opposite sides of bedding plane in a sandy portion of Pottsville conglomerate from Blossburg, Tioga county, Pa.

the conglomerate at other points in Pennsylvania and described by Mr. Arthur Winslow[1] are of similar origin, the only work of solution apparently being the removal of the cement binding the grains together. The disintegration of the conglomerate into sand likewise appears to be unaccompanied by solution, except that of the cement.

Where the etched surfaces are fully exposed to the action of the weather, as on the upper surfaces of ledges, they are, so far as known, always bleached to a gray or white color, but where they are more or less protected, as on the under sides of overhanging ledges, they are almost invariably stained with iron. It is a well-known fact that the action of the humic acids is accompanied by a leaching of the iron constituent, or at least a conversion of the iron to the ferrous state, in which it is ordinarily inconspicuous. The oxidized condition of the overhanging surface would seem, therefore, to indicate that the etching, if due to the action of the organic acids mentioned, is not going on at the present time. The portions of the bowlders in contact with the humus of the soil, though not etched, are distinctly bleached.

Summary of evidence.—The evidences that the etching probably took place in the instances described in the interior of the conglomerate at some past time rather than at the surface under present conditions are as follows:

1. Etching has been noted about vegetable remains at distances of several feet from the nearest exposed surface, showing that the solution is not a superficial feature.

2. Bedding planes extending throughout bowlders of several feet in diameter are frequently etched throughout, indicating the penetration of the solvent to distances of at least a number of feet from the surfaces.

3. The continuations of horizontal etched surfaces, both on the upper and overhanging portions of ledges, frequently extend up to and disappear into the mass of the rock, the exposed

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[1] "Peculiarities of the Weathering in the Pottsville Conglomerate," *Science*, Vol. III, pp. 12–14.

parts, in fact, apparently being portions of much larger surfaces, reaching well into the interior of the rock mass.

4. The etched surfaces, except those about the vegetable remains, appear generally, if not always, to be confined to principal or to cross-bedding planes, or at least to joints, or other planes of separation, such as might have afforded a passage for solutions through the rock. The general absence of etching on surfaces other than the types mentioned, especially on the exposed exteriors of the masses, strongly suggests that the etching was internal.

5. The lack of bleaching on many of the etched surfaces shows that the etching is not the result of organic solvents acting at the present time, and affords negative evidence in favor of internal solution.

Conditions during the etching.—On examining the etched surfaces, it is found that only the immediate exterior is affected, the pebbles and sand grains being pitted or planed down to a general surface, without there being, in most cases, the slightest evidence of solution of the cementing materials (Fig. 3). This evidence tends to show that the rocks were consolidated when the etching took place, and probably indicates rapid action of the etching solutions, for if the rocks were open and porous, as they would have been before consolidation, or if the solutions passed through them for considerable lengths of time, it seems almost certain that the solutions would have penetrated for some distance into the body of the rocks and would have produced an internal etching or disintegration of the portions adjoining the bedding or other planes along which the solutions passed. The existence of small open cavities about the vegetable remains is also probably to be regarded as evidence of the consolidated condition of the rock at the time the solution took place.

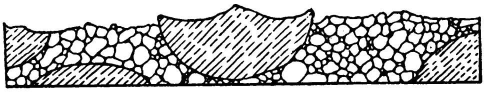

FIG. 3.—Diagrammatic section showing character of etched surfaces of conglomerate. (C. W. HAYES, *Geol. Soc. Am., Bull.*, Vol. VIII., p. 217.)

If the internal nature of the etching of the conglomerate is admitted, the question arises as to whether it occurred while the latter was deeply buried or after it had become exposed at the surface through erosion. The extent of some of the etched surfaces, frequently amounting to several yards, or even rods, and the apparent continuation of these surfaces indefinitely into the rock, though affording no positive evidence, is at least suggestive of deep-seated conditions. The evidence afforded by the bowlders, however, appears to be more to the point, for it is difficult to conceive of conditions which would permit solutions to enter such bedding planes and to penetrate and etch the pebbles throughout their extent, while the external portions of the same bowlders, both where exposed to the atmosphere and to the humus of the soil, are entirely without evidences of etching.

Source and nature of the solvent.—The more sandy portions of the conglomerate at Blossburg contain considerable numbers of feldspathic grains, which, on weathering, it may be conceived, might have afforded alkaline solutions of sufficient strength to have produced an etching of the quartz. The fact, however, that other sandstones and conglomerates higher in feldspathic constituents in equally advanced stages of alteration, do not, in general, show any evidences of etching, makes it improbable, in the present instance, that the alkaline solutions were the active etching agents.

There appears to be no reasonable doubt that the solutions, which produced the etching about the fossil vegetable remains, were derived from the vegetable matter itself, in the process of the change from the original woody state to the present carbonized condition. Vegetable remains are abundant in many parts of the conglomerate, and must have furnished considerable quantities of organic acids. If, in fact, such was the source of the etching solutions, the latter, in order to reach the bedding planes or other passages, must have traversed the mass of the rock, probably through the agency of the force of capillarity. That the portions of the rock thus traversed are lacking in visible etching is probably due to the wide diffusion of the solutions and the relatively immense areas of the surfaces of the constituent grains.

The evidence, as far as it goes, would appear to favor the view that the solvent had its origin in the vegetable matter of the rock itself, that it was concentrated along bedding planes or other passages in the rock, and that it was only where so concentrated that visible etching was produced. The etching is not, however, to be necessarily considered as confined to those parts of the rock abounding in vegetable remains, the solutions probably being conducted by the bedding or other planes to portions remote from the original source of the solvent.

Conclusions.—The observations have been insufficient to warrant broad generalizations, but the evidence, though not so decisive as might be desired, seems to favor, as far as the Blossburg locality is concerned, the conclusions given below. It is not probable, however, that they will hold for the occurrences at all localities.

1. The etching has not taken place under existing conditions. This is indicated by the unetched character of the portions of the rock exposed to the atmosphere or to the humus of the soil, and by the present oxidized condition of most the etched surfaces.

2. The etching is an internal feature, as is indicated by the etching about the plant remains, by the etched interiors of detached blocks, and by the extension of etched surfaces into the mass of the rock.

3. The etching took place after the rock was fully consolidated, as is shown by the fact that it is confined to the immediate walls of the bedding or other planes, the etching solutions failing to penetrate the rock or even to dissolve the cementing material except very locally.

4. The etching is believed to have taken place while the rock was moderately deeply buried, the depth, however, probably not exceeding 500 feet, this being a common limit of the circulation of fresh water below the general surface, as shown by the numerous oil and gas drillings in Pennsylvania.

5. The active solvent was probably an organic acid and was most likely derived from the vegetable remains within the rock itself.

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U. S. GEOLOGICAL SURVEY.